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Cylinder with combination outlet valve and inlet valve for internal combustion engines

A method is described for the charging of an internal combustion engine with cylinders, which have combination outlet and inlet valves (combi-valves). Therein, at least one valve is used for the intake and exhaust of gases. The invention is characterized in that a fast and efficient charging of the combustion chamber is made possible and also in that the combi-valves are cooled during operation.

In addition, a device for the actuation of valves is presented, with which the ratio of the angular velocity of the valve to that of the crankshaft is varied over a brief period of time, so that for a certain period of time an optimally large cross-section is obtained for the discharge of exhaust gases or the admission of fresh gases.

The combination of the two devices is also described.

Description

Background of the Invention

The invention relates to a method and a device for charging a combustion chamber of an internal combustion engine.

In conventional internal combustion engines the cylinders contain valves, which either admit the combustion gas or discharge the exhaust gases, i.e. the discharge and admission of the gases via valves arranged at different locations in the cylinder.

For the purpose of explaining the terms used in the following sections, for which knowledge is presupposed, the following describes briefly the principle of conventional spark ignition engines operating on the four-stroke cycle, with an inlet and an outlet valve.

The individual strokes of the four-stroke cycle are:

1. suction in of the air/fuel mixture or the air
2. compression of the contents of the cylinder
3. combustion and expansion with the output of work
4. discharge of the burnt gases.

The crankshaft, which moves the pistons in the cylinders, normally rotates through an angle $\alpha = 720°$ during these four strokes. The camshaft, which moves the valves, rotates through an angle $\alpha = 360°$ in the same period of time.

At the start of the first stroke the piston is positioned at the top dead center (TDC). This position can be described with $\alpha = \beta = 0°$. During the time, in which the piston moves downwards ($0° < \alpha/2$ or $\beta < 90°$), the inlet valve is open and gas is admitted into the combustion chamber.

During the upward movement of the piston, which now follows (90° < $\alpha/2$ or β < 180°), both valves are closed. The gas is compressed in the combustion chamber. At the top dead center (TDC) position of the piston the gas is ignited; the piston is pushed down again due to the combustion of the gases. At this point in time the valves remain closed. The outlet valve only opens again at a crankshaft angle β of approx. 270°.

For 270° < $\alpha/2$ or β < 360° the outlet valve remains open, the piston moves towards the TDC and the exhaust gases are discharged.

In this conventional process for the charging of the combustion chambers it is not possible, or only possible with difficulty, to admit gases into the combustion chambers quickly and efficiently, since only a limited cross-section of the inlet duct is available. Nowadays attempts are being made to counter this drawback by means of inlet ducts having the form of elliptical cylinders or, for example, by the use of two inlet valves and one outlet valve. However, the cross-section of the outlet ducts cannot be used for the admission of the gases.

The high temperatures of the exhaust gases are such that particularly on high performance engines, it is necessary to make the valve cover heat resistant or to provide adequate cooling. The relatively cold gas that, for example, is sucked in on stroke 1 of the 4-stroke cycle, is not used to cool the outlet valve, although it would be an efficient cooling medium.

Description of the invention

The task of the invention is therefore to find a principle, with which it is possible to make available additional inlet options to those conventionally used for the admission of gases into the combustion chamber of an internal combustion engine and thus to achieve efficient and fast charging of the combustion chamber with gas.

One solution to this task according to the invention is given in Claim 1. Further embodiments of the invention are the subject of the dependent claims.

According to the invention, at least one valve, which is normally used only as an outlet valve, is additionally also used for the admission of gases in one or more cylinders. For the sake of simplicity, these valves are referred to as combi-valves.

In the following it is presupposed that a cylinder is equipped with n inlet and n combi-valves (n = 1, 2, 3...). In relation to a conventional cylinder with 2n conventional valves, this cylinder can now be charged twice as fast, since the sum of the cross-sections of the inlet ducts is doubled in comparison.

On high performance engines it is customary to use a number of inlet and outlet valves per cylinder. For example, combinations are known in which there are 2n inlet valves and n outlet valves. In this case, by using combi-valves in the place of the outlet valves, the charging level of gases into the combustion chamber is increased by the factor 3/2. Other combinations are also conceivable without restricting the generality of the present invention, such as for example 3n inlet valves with n combi-valves (or n with 2n, or 2n with 3n...). Of course, other arbitrary combinations of conventional valves with combi-valves are also possible.

Due to the combination of admission and discharge of the fresh and exhaust gases via the combi-valves according to the invention, these valves are also cooled to some extent.

By means of the method according to the invention it is possible to charge the combustion chambers of internal combustion engines with gas better and faster. It is conceivable, that in each cylinder only combination outlet valves and inlet valves could be used.

Brief description of the drawings

The invention is described in the following without restriction of the general concept of the invention on the basis of examples of embodiments and with reference to the drawings, to which moreover reference is expressly made with regard to the disclosure of all details of the invention not explained in detail in the text.

Fig. 1 shows a view into the cylinder head,

Fig. shows a section through the cylinder head along the line AA in Fig. 1,

Fig. 3 to Fig. 14 show respective sections through the cylinder head, which in their totality represent a sequence schematic of a spark ignition engine operating on the four-stroke cycle (referred to from this point as a 4-stroke Otto engine), which is also referred to as a gas exchange sequence schematic,

Fig. 15 shows the actuation of the rotary slide valve in order to optimize the four-stroke sequence,

Fig. 16 shows a section through the cylinder head of a 4-stroke Otto engine of a further example of an embodiment,

Fig. 17 shows the camshaft control of the 4-stroke Otto engine shown in Fig. 16,

Fig. 18 shows a rotary slide valve construction for a two-cylinder internal combustion engine,

Fig. 19 to Fig. 21 show a further example of an embodiment of a valve head.

Description of examples of embodiments

Fig. 1 shows a view into a cylinder head (1) of an internal combustion engine. In this case two circular inlet valves (2) are provided. The form of the inlet valves is not restricted to that shown; for example, elliptical versions are also possible. Also, in Fig. 1 two combi-valves (3) can be seen, which here are likewise circular in shape, but these could also be elliptical, for example. The combustion chamber (4), which can be of arbitrary shape and includes the spark plugs, is below the center of the cylinder head (1).

Fig. 2 shows a section through the cylinder head on the line AA in Fig. 1. In addition to the combustion chamber (4), the valve bonnets of the inlet valve (2) and the combi-valve (3), the intake ducts (51) and (52) as well as the intake and discharge duct (combi-duct) (53) are shown. A valve, which is represented as in Fig. 2 as a rotary slide valve (or sleeve valve) (6) controls the admission of gas and discharge of gas as described below. The exhaust gas duct (7), on the left side, is closed by the sleeve valve (6). In the place of the rotary slide valve other suitable devices are conceivable for regulating the gas flow, such as e.g. flap valves or valves arranged in a three-valve combination.

Figs 3 to 14 show a sequence schematic for a 4-stroke Otto engine, which in principle and as above, operates as a normal 4-stroke Otto engine. According to the invention, both Otto and diesel engines and even 2-stroke engines with more or less valves are feasible.

In addition to the foregoing drawings, the drawings in Figs 3 to 14 include the cylinder (0) and the camshaft for the combi-valve (31) and the inlet valve (21). The sleeve valve (6) has a cut out (8) in Figs 3 to 14, which can take the form of a routed profile, slot or similar. At a camshaft angle $\beta = 0° = 360°$, which corresponds to a crankshaft angle of $\alpha = 0°$, the piston is positioned at the top dead center (TDC) and the cut out (8) is positioned in such a way relative to the combi-duct (53), that the valve closes the exhaust gas duct (7) and the intake duct (52) (Fig. 3).

A downward movement of the piston results in the creation of low pressure in the cylinder (1) and the fresh gas is sucked into the cylinder through the intake duct (51). At the same time, fresh gas is admitted via the intake duct (52) and the cut out (8) of the rotary slide valve. In this case the valves (2) and (3) are open (Fig. 4 and Fig. 5). By means of a suitable arrangement (e.g. rotary slide valve, double, flap or multiple valve) care must be taken here to close the exhaust gas duct (7). Fig. 4 indicates the direction of flow of the fresh gas. Depending on the embodiment of the participating components, the inward suction of the fresh gas takes place up to a camshaft angle of approx. 90°. It is known that due to the oscillatory characteristics of the gases, even during an upward movement of the piston, i.e. at $\beta > 90°$, it is possible for additional charging of the cylinder to take place for a further period of time (gas resonance). This applies in the case of a conventional inlet valve and also for the combi-valve. At $\beta = 90°$ (Fig. 6) the piston has reached its lowest point.

During the following upward movement of the piston the gas is compressed. The valves are closed and the camshaft rotates from $\beta = 90°$ to $\beta = 180°$ (Fig. 6 to Fig. 9).

Over the range $180° < \beta < 270°$ the piston moves down again, as the combustion takes place (working stroke). The valves remain closed (Fig. 9 to Fig. 12).

Over the range $270° < \beta < 360°$ the combi-valve (3) is open. The cut out (8) is now in such a position that a connection is made between the combi-duct (53) and the exhaust gas duct (7). The exhaust gases flow out from the cylinder as the piston returns towards the TDC (Figs 12 to 14). The direction of flow of the exhaust gases is indicated in Fig. 13.

At $\beta = 360° = 0°$ the cycle has reached the starting point again and the identical sequence is repeated.

At $\beta = 300°$, by means of a suitable variable control of the rotary slide valve drive, of which an example is shown in Fig. 15, it is possible, at the point in time at which the outlet cross-section, which is defined by the cut out (8) in combination with the combi-duct (53) and the exhaust gas duct (7), is a maximum, to cause the rotary slide valve (6) to dwell for a specified period of time in this position, in order then to shortly after accelerate the rotation of this rotary valve. In other words the rotary valve first briefly rotates at a slower rate and then at a faster rate. By this means the largest possible discharge cross-section is guaranteed.

However, as shown in Fig. 15, this device could take a quite different form.

An activation of the rotary slide valve is illustrated in Fig.15. The toothed belt pulley of the rotary slide valve (41) is driven via a chain, a belt or a V-belt (60) by the toothed belt pulley of the crankshaft (51) with, in this example of an embodiment, a 1 to 2 transmission ratio. By pre-tensioning the toothed belt on both sides by suitable means it is possible to displace the angular ratio between the rotary slide valve angle of rotation β and crankshaft angle of rotation α by several units of angular measurement. This movement can be contrived by a suitable eccentric construction or cam drive of such a type, that the pressure rollers (9) or idle rollers (9) exert pressure on the belt (60). According to the invention this functions in such a way, that during the follower action of the idle rollers (9), which press on the belt (60), the angular velocity of the rotary slide valve $d\beta/dt$ relative to the angular velocity of the crankshaft $d\alpha/dt$ is increased or reduced.

In this embodiment described above it would be advantageous either to construct the rotary slide valve completely from ceramic material, or at least to coat it with ceramic material. In the construction of high performance engines it is customary to coat an aluminium alloy with ceramic and then to use this material for valves. In the same way it is advantageous in high performance engines to manufacture the combi-valves from similar material. In accordance with the invention the choice of material can certainly be of benefit, in that both

the slide valve and the combi-valve come into alternating contact with hot exhaust gases and cool fresh gases. By selecting such material an expensive cooling device can be rendered unnecessary.

In order to control the compression in the combustion chamber (4), the combustion chamber (4) could be made variable in length.

Fig. 16 shows a section through a cylinder head, in which in place of the rotary slide valve (6) from Figs 1 to 14, an inlet valve (70) and an outlet valve (71), respectively, are used. The inlet and outlet valves are opened and closed, like the other valves, with camshafts (72, 73). A camshaft actuation of a 4-stroke Otto engine with a combi-valve as a 3-port valve to improve the charging, with which the valves from Fig. 16 can be operated, is represented in Fig. 17. The camshafts (61, 62, 63) are driven by toothed belts (60).

According to the invention even two-cylinder internal combustion engines can be equipped with at least one combi-valve. In Fig. 18, in which an illustration of a rotary slide valve is shown in the upper part of the figure, it is seen that in accordance with the invention two cut outs are provided for the flow ducts. The lower part of Fig. 18 shows sections through the rotary slide valves of the upper part of Fig. 18. In particular the cavities for cooling fluids and the through bore and cut outs for the cooling medium circuit are represented.

Figs 19 to Fig. 21 are illustrations of a 4-stroke Otto engine provided with a combi-valve in accordance with the invention. The upper parts of these figures indicate the positions of the planes on which the sections in the lower parts of the figures have been drawn.

It is again explicitly indicated, that possible embodiments of the invention are presented in the drawings. The invention incorporates among other things the principle of an internal combustion engine, which uses the same valves for the admission and discharge of gases and also the principle of prolonging the time,

during which the exhaust gas ducts and inlet ducts present a relatively large cross-section for the flow.

Claims

1. A method for the charging of the combustion chamber/s of an internal combustion engine, **characterized in that** at least one combustion chamber valve is used as an inlet and as an outlet valve (combi-valve) to achieve a more efficient charging of the combustion chamber/s.

2. The method according to Claim 1, characterized in that at least one additional valve is used as an inlet valve and/or at least one additional valve is used as an outlet valve.

3. The method according to either of Claims 1 or 2, characterized in that at least two valves are used as inlet and outlet valves (combi-valves).

4. A device used to accomplish the method according to any of Claims 1 to 3, characterized in that a combi-duct (53) is connected via a valve with an inlet duct (51 or 52).

5. The device according to any of Claims 1 to 4, characterized in that the combi-duct (53) is connected via a valve with an exhaust gas duct (7).

6. The device according to any of Claims 1 to 5, characterized in that the combi-valve/s takes/take the form of a circular cylinder.

7. The device according to any of Claims 1 to 6, characterized in that the combi-valve/s takes/take the form of an elliptical cylinder.

8. The device according to any of Claims 1 to 7, characterized in that at least one rotary slide valve, one hinged valve, one multi-way valve, one poppet valve, one plug valve, one ball valve or one flap valve is used to control the outlet and inlet of gases from and into the combustion chamber.

9. The device according to any of Claims 1 to 8, characterized in that the inlet of fresh gases through the combi-valve is used for the cooling of the valves.

10. The device according to any of Claims 1 to 9, characterized in that the internal combustion engine operates in accordance with the two-stroke or four-stroke principle.

11. The device according to any of Claims 1 to 10, characterized in that the internal combustion engine is an Otto engine, a Stirling engine, a rotary piston engine or a diesel engine.

12. The device according to any of Claims 1 to 11, characterized in that the valves are manufactured from heat-resistant material, for example ceramic, or are manufactured from aluminium coated with ceramic.

13. The device according to any of Claims 1 to 12, characterized in that the combustion chamber is variable in length in order to control the compression.

14. The device according to any of Claims 1 to 13, characterized in that the opening and closing of the combi-valve is controlled via a double cam.

15. A device for the actuation of at least one valve, in particular according to any of Claims 4 to 14, characterized in that the ratio of the angular velocity of the valve to the angular velocity of the crankshaft is varied over a short period of time.

16. The device according to Claim 15, characterized in that the valve is a rotary slide valve and that the control takes place via pressure rollers, which press on a belt that connects the toothed belt pulleys of the rotary slide valve and the crankshaft together.

17. The device according to either of Claims 15 or 16, characterized in that for a period of time, which is determined by special embodiments, a larger, optimum cross-section is provided for the discharge of the exhaust gases or the admission of fresh gases.

20 pages of drawings attached

Key to the Figures

Zeichnungen Seite ... Drawings Page ...

Fig. 1 : Offenlegungstag date of disclosure

Fig. 3: KW-Winkel = Crankshaft angle, Kurbelwellenzahl = No. of crankshafts

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Fig. 18: Aussparung = Cut out, Strömungskanal = Flow duct

Zylinderkörper = Cylindrical body, Lagerzapfen = Bearing journal,

Hohlraum = Cavity, Kühlflüssigkeit = Cooling fluid,
Bohrung durchgehend = Through-drilled bore
Ausfräsungen = Cut outs,
Schnitt = section

Fig. 19: Frischgase = Fresh gases

Fig. 20: Brennraum = Combustion chamber